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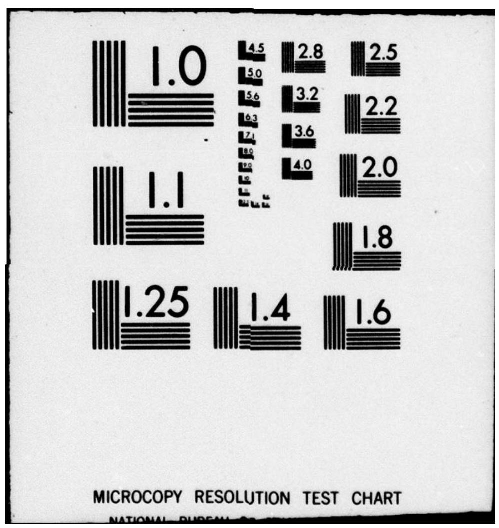
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MINIMUM DATA REQUIREMENTS FOR THE DEVELOPMENT OF TRAINING DEVICES

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MARCH 1978
FINAL REPORT

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This report defines the minimum data requirements for the development of training simulators and suggests cost-effective procedures for obtaining these data. Recommendations are given for contract clauses, Data Item Descriptions, and procedures which should help in obtaining and keeping current the prime materiel system data required to develop the training device so that it can be tested in parallel with the prime system.

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EXECUTIVE SUMMARY

This report is an effort to define the minimum data requirements for the development of training devices and to suggest the most cost-effective procedures for obtaining the data. Recommendations are given for contract clauses, Data Item Descriptions, and procedural methods which should result in obtaining and maintaining currently the prime materiel system data required to develop the training device so that it can be tested in parallel with the prime system. The following conclusions were made.

(1) There is currently considerable confusion within the training community as to the optimum procedure to implement the requirement in AR-1000.

(2) The most critical issue facing the parallel development of training devices is the availability of prime system data which satisfy the fidelity requirements of the simulator.

(3) Data products from Front End Analysis (FEA) can provide, and are the best single source of data to support the parallel development of training devices. Current Army policy does not consider the support of training devices to be a primary role for FEA.

FOREWORD

This research was supported by the U. S. Army Project Manager for Training Devices (PM TRADE) at the Naval Training Equipment Center, Orlando, Florida, and was monitored by the U. S. Army Missile Research and Development Command under Contract No. DAAK40-78-C-0004 sponsored by the Defense Advanced Research Projects Agency.

DISCLAIMER

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MINIMUM DATA REQUIREMENTS FOR
THE DEVELOPMENT OF TRAINING DEVICES

by

Allan S. Chace and Hubert T. Murray

INTRODUCTION

Army Regulation 1000-1[1] titled "Basic Policies for System Acquisition" is currently being revised. A preliminary draft of AR 1000-1 dated September 1, 1977 states that:

> During the Demonstration and Validation Phase, Test and Evaluation will be conducted as appropriate on training simulators, . . . and other subsystems in order that development of these subsystems can parallel the development of (the prime) system prototypes.

Also:

> During Full Scale Engineering Development, the system support package to include integrated technical documentation and training material, . . . and training devices will be developed and tested.

The development of training devices in parallel with the prime weapon systems has been achieved during some relatively simple (non-complex) materiel system developments. For example, STINGER is a man-portable shoulder fired missile system developed by General Dynamics, Pomona, California. This system is basically an advanced version of the fielded RED EYE system which was also developed by General Dynamics, Pomona. Training devices consisted of a conduct-of-fire simulator and a simple handling trainer made from actual components of the prime system as illustrated in Figure 1. Because of the experience of the prime contractor, it was possible to develop these simple training devices in time for the crews to train for Operational Test (OT)-II. In the case of STINGER, training devices were developed in parallel with the prime system as required by the September draft of AR 1000-1.

FIGURE 1. STINGER TRAINING EQUIPMENT

More typically, training devices have not been developed until the design of the prime system is firmly established and validated data describing the prime system are readily available. This typically has occurred following Developmental Test/Operational Test (DT/OT) II. Between DT/OT II and DT/OT III the training devices have been developed and tested.

For example, a 28-months contract to develop a full mission simulator for BLACKHAWK was awarded to the Singer Corporation in August 1976, which was five months after the start of DT/OT II. Following contract award, a 6-months contract extension was granted so that data needed to support the development of the training device could be generated by Sikorsky who was the prime contractor. Clearly, the training device built by Singer could not have been developed in time to be tested during DT/OT II as required by AR 1000-1. The primary limiting factor for earlier development was the availability of data describing the prime system. Lack of prime system data necessary to develop training devices is typically the primary factor which negates the parallel development of training devices.

The Battelle Columbus Laboratories was awarded a contract by the Program Manager, Training Devices (PM TRADE), Orlando, Florida to define the minimum data needed to initiate and continue the parallel development of training devices as required by Army Regulation 1000-1. The primary product of this study is a guide written for the Project Manager (PM) of a prime system. The Guide, published as a separate document provides the PM and other cognizant personnel with a methodology and procedures for identifying and acquiring data which are necessary and sufficient for the development of training devices in parallel with the prime system. Specific recommendations are given for contract clauses, Data Item Descriptions (DID), and procedural methods which will result in obtaining and maintaining currently the prime materiel system data required to develop the training device so that it can be tested in parallel with the prime system.

OBJECTIVE

The objective of this report is to define the minimum data requirements for the development of training devices and to suggest the most cost-effective procedures for obtaining the data.

APPROACH TO THE PROBLEM

The requirement to develop training devices in parallel with the prime system significantly impacts many agencies within TRADOC and DARCOM. Accordingly, several guides and handbooks have been drafted which describe the various Army agencies' means of implementing AR 1000-1, once it is released. Two of the current draft reports are References 2 and 3. These draft guides and other supporting documentation were obtained for use during this study.

Because of the current state of uncertainty in implementing AR 1000-1, personnel with in-depth experience in simulator development were found to be a valuable source of information for this study. Therefore, numerous visits and contacts were made to gather the most current information and insight as to minimum data requirements and how such data could be obtained to support the development of training devices in parallel with the prime system. Table 1 shows a list of persons contacted during this study.

Individuals contacted from Army agencies provided Army policy statements, draft guides and other documentation and insight as to the practical means of implementing AR 1000-1. Individuals contacted from private industry described the data needed by contractors to develop training devices. Their views regarding the early development of training devices was also carefully noted.

The collected data were assembled and analyzed. This report is based upon the finding of that analysis.

TECHNICAL DISCUSSION

Assumptions

This study and the preparation of the Guide were based upon three critical assumptions in accordance with the statement of work for this effort.

TABLE 1. PERSONS CONTACTED DURING THIS STUDY

Personnel	Agency	Method of Contact
Major Hampton	Training Development Institute Ft. Eustis	Phone
Robert Ballard	Training Development Division Ft. Monroe	Visit
Lt. Col. Maynard	Aviation Systems PM TRADE	Visit
Mr. J. A. Wessel	Burtek, Inc. Tulsa, Oklahoma	Visit
Mr. James Ferguson	Educational Computer Corporation Orlando, Florida	Visit
Major Drews	XM-1 PM TRADE Orlando, Florida	Visit
Mr. James Hamill	Armor School Fort Knox	Phone
Mr. Bill Parr	HELLFIRE U. S. Army Missile Command	Phone
Major Hampton	Ft. Eustis	Visit
Mr. John Peer	Maintenance Management Center Lexington, Kentucky	Visit
Mr. William Dates	Maintenance Management Center Lexington, Kentucky	Visit
Mr. Robert Middleton	Westinghouse Corporation Baltimore, Maryland	Phone
Mr. Robert Shapiro	Westinghouse Corporation Baltimore, Maryland	Phone
Captain Larry Trimble Mr. Edward North Mr. Les Sanders Mr. Ray Edmonson	Missile & Munition Center & School Redstone Arsenal, Alabama	Visit

Table 1 (continued)

Personnel	Agency	Method of Contact
Mr. Joe Thompson	PM TRADE	Visit
Mr. Robert Dybas	PM TRADE	Visit
Mr. Conrad Bussey	BLACK HAWK Project Office	Visit
Mr. Frank Thomas	BLACK HAWK Project Office	Phone
Mr. James Stahl	Singer Binghamton, New York	Visit
Mr. Charles Monachello	Singer Binghamton, New York	Visit
Mr. John Donnellon	Singer Binghamton, New York	Visit
Mr. Dave Clutz	Singer Binghamton, New York	Visit
Dr. Robert Odom	PM TRADE Field Office Ft. Eustis	Visit
Col. Swearen	Training Integration Office Ft. Eustis	Visit
Mr. Robert Ballard	Training Integration Office Ft. Eustis	Visit
Mr. Francis Coombs	Training Integration Office Ft. Eustis	Visit
Mr. Donald Jones Major Robert White	Firefinder, Orlando	Visit
Mr. Joe Anderson		Visit
Mr. Emile Luft	Dragon Program Office US Army Missile Command Redstone Arsenal, Alabama	Phone
Mr. Joe Collier	STINGER Project Office US Army Missile Command Redstone Arsenal, Alabama	Visit

Table 1 (continued)

Personnel	Agency	Method of Contact
Mr. Kenneth Burke	STINGER Project Office US Army Missile Command Redstone Arsenal, Alabama	Visit
Major Robert Starr	Training Support Center Ft. Eustis	Visit
Major James Wool	Training Support Center Ft. Eustis	Visit
Col. Don Meeks	Simulator System Project Office Wright-Patterson Air Force Base Dayton, Ohio	Visit

These assumptions were that:

(1) Training devices <u>must be</u> developed within the policies of the September 1, 1977 draft of AR 1000-1. In particular it is assumed that:

(a) "During the Demonstration and Validation Phase, test and evaluation will be conducted as appropriate on training systems. . . and other subsystems in order that development of these subsystems can parallel the development of (the prime) system prototype."

(b) "During Full Scale Engineering Development, the systems support package to include integrated technical documentation and training material. . . and training devices will be developed and tested."

(2) Data sources which support the development of training material will be available as stated in the following draft reports:

(a) <u>TSM Guide to Training Development and Acquisition for Major Systems</u>[2], DRAFT, December (1971), pp. 4-36.

(b) <u>Technical Documentation and Training Acquisition Handbook</u>[3], First Draft, January (1977), revised May (1977), pp. 1-1, 4-28.

(3) The guide is primarily for the development of training devices by a contractor other than the prime contractor.

<u>Data Selection Criteria</u>

During the course of this study a number of options for obtaining data to support training device development were considered[4, 5]. The recommended procedure described in Chapter 2 of the Battelle prepared guide was finally selected because it best satisfied the following criteria established for the selection of the data. These data selection criteria are:

1. The cost of the data should be minimal.
2. The liability of the government should be as small as possible.

3. Data should not be delivered to the training device contractor unless they are necessary to support simulator or training device development.

4. The training device contractor must have access to all data which are required to develop the training device. The data must be sufficient to support training device development.

REQUIREMENTS FOR MINIMUM DATA

RFP Data

During the course of this study contractors for training devices were asked to describe what minimum data they needed to properly respond to the RFP. They independently agreed that the minimum data requirements vary according to the training devices being developed. Variable factors include the complexity of the training device, the completeness of available prime system documentation, the contractor's prior knowledge of the prime system, and the intended application of the proposed simulator.

It was noted for example, that the maintenance training device for the EA-6BICAP Jamming System was built without any special data being prepared to support the proposal for the training device. In addition, the prime contractor was never contacted to provide any information to support the development of the training devices throughout the entire development program. All data describing the prime system were obtained from the Naval Air Systems Development Command by reviewing reports Grumman had produced for the Navy to support contractual arrangements unrelated to training simulators. Although this was unusual, it illustrates that there are cases where the government does not need to spend much money to prepare and deliver data to the training device contractor, and that a great deal of data are available in a well documented program to support the proposal and subsequent development of training devices.

More typically, all contractors of part task training devices interviewed during this study prefer the following information to support their development program. They prefer that these data are made available at the time the RFP is prepared but this is not absolutely necessary:

- Operation manual (i.e., flight manual)
- Portions of the maintenance manual which describe the subsystem being simulated (i.e., electrical, fuel, etc.)
- Wiring or plumbing diagrams if they are pertinent to the simulator
- Fault isolation manuals
- Instrument panel drawings if they apply
- Layout drawings of the prime system.

In addition, they need to discuss directly with the prime contractor the availability and timing of revised data, the future generation of new data and in some cases the availability of prime system components.

One individual employed by a relatively small contractor also expressed the opinion that in addition to the above information he would like to see a student profile for those persons who will be using the training devices. This information should include a task analysis as well as the education and experience level of the student. If this information were provided, he felt that training devices could be proposed which would be more suitable to the needs of the student. He also noted that a lack of data provided with the RFP could result in a higher proposed cost because the training device contractor must allow for the purchase of data as a special item.

A recent study[6,7] completed by the Air Force generally supports the view that those responsible for developing training devices would like a relatively complete RFP data package. Currently each training device contractor obtains all data directly from the prime contractor. Quoting from the Air Force Study:

> "What the simulator manufacturers would like is for the Government to collect the data package in one place. When an RFP is contemplated, announce the fact and send all manufacturers who qualify for the RFP a list of the data collected and an invitation to review the data package. Have the competition based on that data package, which will be delivered to the winning contractor, and have all simulator specifications referenced to that data baseline. Of course provisions will have to be made for updating this data package at intervals, preferably not more than two, while the simulator is being developed."

It is concluded that it would generally be desirable to provide a fairly complete physical and performance description of the prime system with the RFP if this information can be obtained at low cost.

Complete Data Package

All personnel who were interviewed and reports which were read[6,7] emphasized that a complete data package was required soon after contract award. These data must be delivered prior to or at the middle of the initial design phase. These data should provide a complete physical and operational description of the prime system. Performance data as discussed in Appendix A are desirable but not required for delivery with the complete data package. Performance data are required before acceptance tests are prepared or fabrication is begun.

It will be necessary to update the complete data package as the development of the prime system progresses. It is important that all conflicts between the complete data package, and updates to this package be resolved. The Air Force study mentioned earlier illustrates the importance of this requirement[6,7]:

> "A great many problems have centered around the (simulator) Acceptance Test Procedures (ATP) in the past. In general these are caused by writing the ATP around a data package that is different from the one that has been approved as the basis for the design of the simulator. The simulator is then tested to this later data. Whether or not the simulator passes these tests is a measure of how accurately the approved data package represented the real weapon system and not of how accurately the contractor has duplicated a system represented by the data package."

In addition to the complete data package, additional engineering support services and special reports from the prime contractor are required. The need for this support varies with the quality of the data provided to the training device contractor with the RFP and in the complete data package. A bidders conference should be held at the outset to explain exactly what data products will be provided by the DoD. Special reports are often required to document system performance data. The PM should assure that performance data (see Appendix A) will be included in the system and subsystem specifications so that the number of such special reports will be minimized.

The PM must encourage a good working relationship between the prime contractor as was noted in References 6 and 7.

- Three simulators were studied where the simulator contractor supplied a well qualified simulator engineer on-site in the weapon system contractor's engineering department to assist in pulling together the data package. These men were given free access to all engineers. In all three cases the data packages were complete, supplied on time, and to the level of accuracy available to the aircraft manufacturers. The follow-up inquiries were well organized and generally quite fruitful.

It was also noted that:

- In several cases the simulator manufacturer has been supplied with an experienced pilot to attempt to get the simulator to fly like the airplane in the absence of a good data package. This has been successfully accomplished when the project pilot supplied is an experienced test pilot and where he has access to the aircraft being simulated so that he can alternate actual flight with simulator testing.

Recommended Minimum Data

Standard data products produced by the prime contractor which are needed to support the development of training devices are shown in Table 2. Delivery schedules for specific data will vary from one type of trainer to another. Both the schedule and detail of the data will be different for simple versus complex training devices. However, in all cases an initial data package must be delivered so that it will accompany the RFP data package sent to potential training device contractors. For operator training simulators this RFP data package will include Items a. through f., as defined in Table 2. For maintenance training simulators the RFP data package will include Items a. through i.

Halfway through the initial design phase of the training device, a complete data package is required. This consists of an update of all data products delivered with the RFP data package; Items g. through k., for operator training simulators; and Items j. through m., for maintenance training simulators.

The complete data package should be updated as follows. All data products delivered with the complete data package will be updated at the

TABLE 2. MINIMUM DATA REQUIREMENTS

Operator training simulators

1. Data provided for operator training simulation will include:

   a. One copy of each selected drawing related to the system and subsystem(s) for which the training device is being developed. Support diagrams and photographs should also be provided if they are available.

   b. System and subsystem specifications related to the subsystem(s) for which the training device is being developed.

   c. Functional descriptions.

   d. Block diagrams.

   e. Functional breakdown diagrams.

   f. Behavioral task analysis material.

   g. Assembly schematics.

   h. Detailed assembly schematics.

   i. Failure symptom report.

   j. Approved engineering change proposals (if available).

2. Maintenance Trainers - Data provided for maintenance trainers will include:

   a. One copy each of selected drawing related to the subsystem(s) for which the training device is being developed. Support diagrams and photographs should also be provided if they are available.

   b. Subsystem specifications related to the subsystem(s) for which the training device is being developed.

   c. Special training device requirements.

   d. Maintenance allocation chart.

   e. Functional breakdown diagrams.

   f. Block diagrams.

   g. Functional description.

Table 2 (continued)

h. Behavioral task analysis material.

i. Tools and test equipment.

j. Assembly schematics for the subsystem(s) being simulated.

k. Detailed assembly schematics for instruments and components being simulated.

l. Failure symptom analysis.

m. Approved engineering change proposals (if available).

beginning of the design and fabrication phase of simulator development for operator and maintenance simulation requiring more than 18 months to develop.

Data products will not require update for simulation requiring less than 18 months to develop. In all cases, however, approved engineering change proposals and specification change notices for the prime system that related to the training device being developed (Item j., k., and m. in Table 2) will be delivered directly to the training device contractor as produced. Newly acquired dynamic or performance data documented in system and/or subsystem specifications should be delivered at periodic intervals of three months.

In addition to the above data, the contractor for the training devices should be allowed to purchase engineering services and special reports directly from the prime contractor under a separate agreement.

KEY SOURCES OF DATA

A number of standard data products are routinely produced during the prime system development cycle which could potentially support the development of training devices. These data include front end analysis (FEA) products, logistic support analysis record (LSAR), drawings, specifications, and engineering change proposals. The use of existing data products to support training device development is recommended because the costs involved are only those for reproduction and distribution. In this section the optimum selection of data to support the training device program is discussed.

Mil Standard 480, Configuration Control-Engineering Charges, Deviations and Waivers, states in paragraph 1.2.1 that "Contractors will specifically define base line documentation and change requirements consistent with the scope of the program and the complexity of the item being procured." The PM must, of course, approve of the contractor's documentation and change requirements.

In practice, the PM typically does not control drawings and other documentation related to detailed prime system configuration when the training device is initially being developed. Unofficial drawings, which are subject to change, are however, available from the prime contractor. It is recommended that the PM carefully select only a few of these drawings to support the training device development program. This selection should avoid priority data. The PM should also provide approved engineering change proposals and specification change notices if they are available and relate to the training device.

The similarity between LSAR and FEA is noted in a reference[8] which describe LSA action necessary to satisfy FEA requirements. It is shown, for example, that LSA-20 output summary will satisfy the FEA tool and test equipment list requirements; and that the FEA Maintenance Allocation Chart is satisfied by LSA-04. Similarly, this reference shows how each LSAR data product is related to each of the FEA products. It was decided during this study that both sources of information generally should not be provided to training device contractors at government expense because they contain similar information. The delivery of FEA data products is recommended because:

(1) FEA data are prepared to support a training program for the prime system, whereas LSAR data are prepared for multiple application. Therefore, training devices developed from FEA data will likely be more compatible with the total training program, and the FEA documentation will be directed more to the needs of the training device development.

(2) FEA data are generated from the LSAR data and other input sources. Therefore, conflicts within these data should be resolved in the FEA reports; and the FEA data should provide a more complete description of the prime system.

(3) Personnel preparing the FEA can provide a more meaningful source of Engineering Service Support for the Training Device Contractor since they are likely to be more familiar with training problems than personnel preparing the LSAR.

It should be noted that a high ranking individual employed by a manufacturer of part task training device reported that if the LSAR is well documented, then this source of information is well suited to support the development of training devices. In some cases it is even preferable because of its summary form. On the other hand, personnel preparing the FEA for a major weapon system noted that the LSAR data they encountered often contained errors, and was formatted so that many partially blank data sheets were produced. In their opinion the FEA products were far superior to support the development of training devices.

Data Item	Maintenance Trainers	Operator Trainers	Source	References
Drawings	X	X	Selected Drawings	DI-E-7013A (Level 1) MIL-D-1000A MIL. St. 100B
System/Subsystem Specifications	X	X	Selected Specifications	DI-E-1104
Dynamic Data	X	X	Specification and Drawings or Special Reports	DI-E-1104 DI-E-7013A
Approved Engineering Change Proposals	X	X	Selected ECP's (if available)	MIL. St. 480
Specification Change Notices	X		Selected SCN's (if available)	DI-E-1126 MIL. St. 490
Maintenance Allocation Chart	X		FEA	MIL-M-63035
Functional Breakdown Diagrams	X	X	FEA	MIL-M-63035
Block Diagrams	X	X	FEA	MIL-M-63035
Functional Descriptions	X	X	FEA	MIL-M-63035
Assembly Schematics	X	X	FEA	MIL-M-63035
Detailed Assembly Schematics	X	X	FEA	MIL-M-63035
Behavioral Task Analysis Material or Preliminary Task Analysis Worksheet	X	X	FEA	MIL-M-63035
Special Training Device Requirements (LSA-11)	X		LSAR	AMCP 750-16 DI-S-1818A DI-S-6XXX
Tools and Equipment Requirements	X		FEA	MIL-M-63035
Failure Symptoms Report	X	X	Special Report from FEA	MIL-M-63035

TABLE 3. SUMMARY OF DATA REQUIREMENTS FOR TRAINING DEVICES

Once the decision was made to rely on FEA data rather than LSAR data as the primary support for the development of training devices, it follows that the entire FEA process should be closely integrated with the training device development programs. Unfortunately many current documents do not consider the support of training devices to be a primary role for FEA. For example, Mil Standard 63035 requires a failure symptom analysis of the system; but there is the formal report requirement for this data which is needed by the training device contractor. The FEA products should be written so that data needed to support the development of training devices will be available. It is recommended that specifications for FEA consider data requirements to support training devices.

FEA data products can be obtained at a cost which is not excessive. For example: the complete set of FEA data for the XM-1 was reported to fill a three-shelved book case about 3 feet long. If it is assumed that there are an average of 200 pages of text per inch, and that the average cost of reproducing each page in quantity is $0.05, then it follows that a complete set of FEA data for the XM-1 can be obtained for about $1,000.00. The maximum cost of data to support the RFP is estimated at a few hundred dollars per contractor.

It is concluded that the data sources shown in Table 3 should be used to support the development of training devices. The delivery of these items should be as stated in the previous section.

SUGGESTED CONTRACT CLAUSES

The most effective way to assure that data to develop training devices are available when needed is to insert contractual clauses directly into the RFP and contract for the prime system. Suggested inserts are given in this section.

Engineering Services and Special Reports

The following clause should be inserted into the contract and RFP for the prime system to assure that data needed to support the development of training devices is obtained:

"The contractor must provide consulting engineering services and prepare special reports as requested by the training device contractor. The costs involved will be paid for by the training device contractor under separate agreements. Engineering services shall include, but not be limited to resolution of questions and interpretation of prime system data; review of simulator test or design criteria; review of system operating and performance characteristics and effects; liaison with Government trainer procuring activity personnel; liaison with vendors for contractor-furnished equipment; participation at the trainer mockup and design review; and provision for test operator's participation in testing of the trainer. Special reports shall include, but not be limited to, obtaining photographs and movies of the system in operation, description of the dynamic performance characteristic throughout special operational regions of the system, special drawings, and LSAR input sheets and reports. All subcontractors of the contracts are likewise required to provide consulting engineering services and special reports."

Limited Versus Unlimited Rights

Armed Services Procurement Regulation ASPR 7-104.9, Rights in Technical Data and Computer Software, describes the appropriate clauses to be applied for technical data. An attempt should be made to negotiate all data required for the development of training devices under the "Unlimited Rights" clause.

The "Limited Rights" clause in ASPR 7-104.9, Rights in Technical Data and Computer Software, states that:

(8) Limited Rights means rights to use, duplicate, or disclose technical data, in whole or in part, by or for the Government, with the express limitation that such technical data shall not without the written permission of the party furnishing such technical data be (a) released or disclosed in whole or in part outside the Government, (b) used in whole or in part by the Government for manufacture, or in the case of computer software documentation, for preparing the same or similar computer software, or (c) used by a party other than the Government, except for:

(i) emergency repair or overhaul work only, by or for the Government, where the item or process concerned is not otherwise reasonably available to enable timely performance of the work, *provided* that the release or disclosure thereof outside the Government shall be made subject to a prohibition against further use, release or disclosure; or

If the negotiation must be under the "Limited Rights" clause, the following sub-clause should also be incorporated as follows:

> (ii) the development of training devices, provided that the release or disclosure thereof outside the Government shall be made subject to a prohibition against further use, release or disclosure.

Data Item Description

In addition to the contract clauses, a DID should be incorporated into the prime RFP for Front End Analysis in accordance with MIL-M-63035. The PM must include a special Failure Symptoms Analysis Report in this DID in accordance with MIL-M-63035. Additional DID's should be incorporated for the drawings, Specification and Logistic Support Analysis Plan, and Logistic Support Analysis Record. The PM must assure that the delivery schedule for these data products is in agreement with the delivery schedule required to support training device development.

Subcontract Clauses

The primary problems in acquiring data to support training device development do not occur with the prime system contractor, but rather with prime system subcontractors. The preceding contract clauses for Engineering Services and Special Reports, and for Limited Rights must therefore be inserted into all of the subcontracts of the prime. The preceding clauses will assure that the training device contractor can obtain the needed assistance directly from prime system subcontractors if required.

POTENTIAL PROBLEMS

The most critical problem concerning the development of training devices in parallel with the prime system is the availability of adequate prime system data. The PM must assure that the prime system will be sufficiently developed so that the level of detail of the prime system data will be sufficient to support the development of the training devices. In particular, data describing the detailed performance of the prime system will not be available until field tests of the prime system are analyzed. Many of the field tests are performed just prior to DT/OT, so there is insufficient time to include the test results in the simulator. Aircraft manufacturers estimate that aerodynamic performance data are usually available five to eight months following flight tests[6,7].

If the prime system undergoes significant changes as a result of DT/OT testing, then major changes are likely to occur for the training devices. Such modifications can be very expensive.

Personnel at the Air Force Simulator SPO were asked to express their views on how early in the prime system development cycle it would be practical to develop training devices. They reported that the Air Force does not develop aircraft simulators until the production configuration is approved. Earlier development of flight simulators has shown that significant increases in cost occur because of changes in the prime system. These views were verified by personnel from a large simulator manufacturer.

During the course of a prime system development, the PM may find that his funds have become limited or that the prime system development schedule is lagging. When either of these conditions occur, the PM will be tempted to reduce the requirement for the prime contractor to document the state of the prime system because their policy will produce a temporary time and dollar savings. If this occurs, the development of training devices in parallel with the prime system may not be feasible.

If the two prime systems are being developed during Full Scale Engineering for competitive evaluation, as in the case of BLACKHAWK, then training devices will be required for each system. The prime contractor may be reluctant to provide performance data to support training devices development because of the competitive nature of the development.

It was established that FEA data should support the development of training devices, and that specifications for the FEA be written accordingly. Unfortunately, the specific needs for training devices cannot be determined until the FEA is nearly complete, because specifications for training devices must be based upon a list of training tasks established at the end of FEA[9]. It is therefore recommended that candidate specifications for training devices first be established to impact the data requirements for FEA.

OBSERVATIONS

The requirements to develop training devices in parallel with the prime system may persuade the PM to always award a development contract to the prime rather than an independant contractor. This approach is attractive because it will ease the PM's administrative responsibilities particularly in the area of data collection. Awarding a training device development contract to the prime for simple training devices such as STINGER, appears advisable and is well justified on historical basis. However, such an award is not advisable when the complexity of the training device demands that the prime contractor award a large subcontract for the development. In this case, it is recommended that the PM award a contract directly to the training device contractor because:

(1) The total cost for developing the training devices will be reduced significantly by eliminating the requirements for the prime contractor's administrative and supervisory costs.

(2) Additional acceptance tests for the prime contractor will be eliminated.

(3) More direct communication between the training device contractor and the user of the training devices will occur.

Two cases are noted where the prime contractor did in fact subcontract the development of complex training devices. In both cases, development costs were high, as noted above. In particular, Lockheed awarded a subcontract to Link-Singer to develop two training devices for the Viking S3-A Antisubmarine Warfare Aircraft; and General Dynamics awarded Link-Singer a subcontract to develop simulators for the F-111 aircraft.

It remains for the PM to decide whether the prime contractor should be awarded a sole-source contract to develop the training device; or whether an independent contractor is required. If an independent contractor is selected, then the contents of this report and Guide are of primary importance. If the prime contractor also develops the training devices, the PM still should carefully evaluate the delivery schedules for the data products as stated in the Guide. This evaluation is important because data products should be scheduled such that the prime system documentation is always in the optimal form to support the timely development of training devices.

CONCLUSIONS

1. The most critical issue facing the parallel development of training devices is the availability of prime system data which satisfy the fidelity requirements of the simulator.

2. There is currently considerable confusion within the training community as to the optimum procedure to implement the requirement in AR-1000.

3. Data products from Front End Analysis can provide, and are the best single source of data to support the parallel development of training devices. Current Army policy does not consider the support of training devices to be a primary role for FEA.

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(3) "Technical Documentation and Training Acquisition Handbook", First Draft, Sources not given, pp 1-1, 4-28 (January 1977; revised May 1977). PM ARTADS.

(4) "Life Cycle System Management Model for Army Systems", Pamphlet, Headquarters, Department of the Army, pp 11-25 (May 1975).

(5) "DARCOM/TRADOC Policy Statement on Integrated Technical Documentation and Training (ITDT)", pp 1-14 (August 1977).

(6) "Aircraft Simulator Data Requirements Study", Executive Summary, Technical Report No. ASD-TR-77-25, Volume I, Systems Research Laboratories, Inc. (January 1977).

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(8) "DARCOM C1, AMCP 750-16 DARCOM Guide to Logistic Support Analysis; APPENDIX G: Development of Integrated Technical Documentation and Training Materials Utilizing Logistic Support Analysis" (DRAFT), U. S. Army DARCOM Material Readiness Support Activity (January 1978).

(9) "DARCOM/TRADOC Policy Statement of Integrated Technical Documentation and Training (ITDT)", Department of the Army, Headquarters U. S. Army Training and Doctrine Command, Fort Monroe, Virginia and Headquarters U. S. Army Materiel Development and Readiness Command, Alexandria, Virginia, 6pp. (December 19, 1977).

APPENDIX A

PRIME SYSTEM DYNAMIC PERFORMANCE DATA
REQUIRED FOR SELECTED ARMY TRAINING DEVICES

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PRIME SYSTEM DYNAMIC PERFORMANCE DATA REQUIRED FOR SELECTED ARMY TRAINING DEVICES

This appendix identifies prime system data which are likely to be required to simulate the dynamics of Army missiles, Wheeled Vehicles, Tracked Vehicles, and Tactical Radar and Reciprocating Engines. Data required to simulate fixed-wing aircraft and their subsystems are available in the following references:

MIL-D-23143 (Wep)	"Military Specification Data, Technical Aircraft; for Design of Aviation Training Devices"
UT-3920A-ASD	"Simulator Design Data Requirements".

The PM of a prime weapon system should review this appendix to become familiar with the type of performance data typically required to develop simulators. He should then assure that such data will normally be documented within the system and subsystem performance specifications generated by the prime contractor. Failure to assure that the data are available may result in additional data cost.

The required data are generated through theoretical analysis or experimental tests and typically published in tabular or graphic form. The required data may vary as a function of several parameters which are not discussed in this Appendix. For example the lift coefficient of a missle varies as a function of control surface deflection at various Mach numbers, angle of attack, and Reynolds numbers, as well as rate of control deflection.

General Performance Data Required to Simulate the Dynamics of Wheeled or Tracked Vehicles

- Body (sprung) mass
- Body (sprung) mass moment of inertia
  - Pitch
  - Roll
  - Yaw

- Body structural resonances
  (0 to 10-Hz frequency range)
  - Mode shape
  - Frequency
  - Damping
- Body geometry
  - C.G. location
  - Wheel/axle suspension locations
- Brake system pressure vs pedal force
- Brake torque per wheel vs brake pressure (including hydraulic system dynamic time lags)
- Drum/disc brake dynamics (including power-assist dynamics)
- Drum/disc temperature vs energy dissipation vs time
- Brake torque vs temperature of drum/disc
- Wheel lock (skid) limits
- Wheel yaw angle vs steering wheel/levers position
- Steering wheel torque vs yaw torque and lateral force
- Power steering dynamics

<u>Additional Performance Data Required to Simulate the Dynamics of Wheeled Vehicles</u>

<u>Dual Characterization (Main List), Wheeled Vehicle</u>

- Wheel/axis masses
- Wheel/axle mass moments of inertia
  - Roll
  - Yaw
- Driven wheels mass moment of inertia about axis of driven rotation

- Wheel/axle geometry
  - C.G. locations
  - Suspension locations
  - Kinematic linkage between wheels/axles
- Suspension characteristics
  - Stiffness vs stroke
  - Damping vs stroke velocity
  - Stroke limits
  - Damping force limits
  - Suspension kinematics
- Tire characteristics
  - Stiffness (load/deflection) on level surface
    - -- Vertical
    - -- Lateral
    - -- Longitudinal
  - Damping (load/velocity) on level surface
  - Nominal loaded rolling radius of tire
    - -- Drive wheels
    - -- Support wheels
  - Obstacle-enveloping characteristics (stiffness, damping)
  - Tire/soft soil penetration
  - Rolling resistance
    - -- Level, hard surface
    - -- Soft soil
  - Traction and braking limits ("coefficient of friction") vs forward velocity (function of relative slip rate, normal force)
  - Lateral force on tire vs wheel slip angle (function of normal force, forward speed)
  - Tire yaw torque vs wheel slip angle (function of normal force and forward speed)

Additional Performance Data Required to Simulate the Dynamics of Tracked Vehicles

- Road wheel masses
- Drive sprocket and track (effective) mass moment of inertia about axis of drive rotation
- Road wheel geometry
  - C.G. locations
  - Suspension locations
  - Kinematic linkage between road wheel and idler
- Suspension characteristics
  - Stiffness vs stroke
  - Damping vs stroke velocity
  - Stroke limits
  - Damping force limits
  - Suspension kinematics
- Track characteristics
  - Track/road wheel stiffness on level surface
    - Vertical
    - Lateral
    - Longitudinal
  - Track/road wheel damping on level surface
  - Nominal loaded rolling radius of track/road wheels (level surface)
  - Nominal driving radius of drive sprocket
  - Track compliance (drive sprocket to driven surface)
  - Track rolling (traction) resistance
    - Compaction resistance
    - Bulldozing resistance
    - Side-drag resistance
  - Traction and braking limits ("coefficient of friction") vs forward velocity (function of relative slip rate, normal force)
  - Lateral force on track vs slip angle (function of normal force, forward speed)

- Track yaw torque vs slip angle (function of normal force, forward speed)
- Track interactive forces (obstacle-enveloping stiffness) between road wheels
- Track tension
- Track weight
- Track length
- Track stiffness (longitudinal)

Performance Data Required to Simulate the Dynamics of Ground-to-Ground or Ground-to-Air Missiles

A_r	reference area
C_A	axial-force coefficient, $\frac{F_\alpha}{q_\infty A_r}$
C_{d_n}	crossflow drag coefficient of circular cylinder section, $\frac{F_n}{a_n(\Delta_{cy})d_{cy}}$
C_D	drag coefficient, $\frac{drag}{q_\infty A_r}$
C_L	lift coefficient, $\frac{lift}{q_\infty A_r}$
C_m	pitching-moment coefficient about station at x_m from nose, $\frac{\text{pitching moment}}{q_\infty A_r X}$
C_N	normal-force coefficient, $\frac{F_n}{q_\infty A_r}$
C_n	local normal-force coefficient per unit length
C_p	pressure coefficient, $\frac{p - p_\infty}{q_\infty}$
C_Y	side-force coefficient, $\frac{F_y}{q_\infty A_r}$
d	body cross-section diameter
F_a, F_n, F_y	axial, normal, and side force
ℓ	body length
M_∞	free-stream Mach number
p	pressure

p_∞	free-stream static pressure
q_n	dynamic pressure component normal to body axis, q $\sin^2$
q_∞	free-stream dynamic pressure, $\frac{1}{2}\ V^2$
Re	free-stream Reynolds number, $\frac{\rho V_\infty X}{\mu}$
Re_n	Reynolds number component normal to body axis, Re $\frac{d}{X}$ sin α
V_n	velocity component normal to body axis, $V_\infty \sin\alpha$
V_∞	free-stream velocity
X	reference length
α	angle of attack
β	angle of sideslip
ρ	density of air

Subscripts

cy	cylinder

Performance Data Required to Simulate Tactical Radar Systems

Types of Radar

- Forward looking (air-to-ground)
- Side looking (air-to-ground)
  - Synthetic aperture
  - Conventional mapping
- Ground-to-ground
  - MTI - search
- Ground-to-air
  - Search
  - Tracking

Modes

- Pulse
- Doppler
- Chirp/chirp ratio
- CW
- Pulse compression
- Coherent/incoherent
- Range gating
- Velocity gating
- Delay line canceller MTI
- Range-gated filter MTI

Radar Systems Data

- Antenna
  - Mechanical/phased array
  - Scan pattern generator equations
  - Horizontal/vertical beam width
  - Tracking equations
  - Depression/elevation angle of beam
  - Radiation pattern for all modes
  - Side lobes/suppression
  - Stabilization platform transfer function with respect to aircraft and ground references
  - Scan rate(s) (azimuth, elevation)
  - Scan angles
- Transmitter
  - Variations in PRF
  - PPE in each mode
  - Variations in carrier frequency
  - Pulse width in each mode

- Waveform
- Peak and mean power out
- Coherency of output
- Frequency
- Doppler spread due to PRF deviations
- Special capabilities - jitter, pulse compression, stagger, etc.

- Receiver (each item as a function of mode)
  - AGC characteristics, MGC characteristics
  - Threshold S/N
  - Lin/log characteristics
  - Noise power
  - Minimum detectable level (i.e., detection capability)
  - Attenuation of plumbing
  - Special processing for displays (e.g., doppler filtering)
  - Interface signals and signal strength for tracking system and display system
  - Noise figures
  - Special effects such as response to jamming, etc.
  - Video bandwidth
  - Upper and lower corner of filter
  - Dynamic range

- Tracking system (each item as a function of radar mode)
  - Ranging capability max/min ranges, range rate
  - Angular rates/capabilities/resolutions
  - Velocity capability
  - Tracking accuracies with phase, amplitude variations
  - Lock-on characteristics in terms of signal strength and range rate
  - Conical scan; sequential lobing; monopulse
  - Resistance to jamming (e.g., range gate stealer)
  - Break lock criteria such as signal strength, manual control, etc.
  - A/G ranging criteria
  - Details of interface with other displays (proving, photographs, diagrams, fire control system, and on-board computer)

- Display system (each item for each radar mode)
    - Photographs, movies or videotapes of displays to illustrate effects of radar mode and noise, jamming, target returns, annotating environmental conditions and equipment status
- Platform characteristics
    - Speed
    - Altitude
    - Stability (RMS role, pitch yaw)
- Target/background characteristics
    - Orientation (cross section), dbsm
    - Velocity relative to platform
    - Angular direction of target motion selective to radar
    - Clutter (background) cross section per square meter
    - Target area projected toward radar
    - Camouflage degradation factors
    - Number of targets
    - Types and extent of backgrounds around target (and cross sections), dbsm
- Weather
    - Rain rates
    - Snow rates in equivalent wetted area
    - Weather as function of altitude
        - -- Rates and water content at each atmospheric layer (rain, snow, clouds, winds)
    - Total path length attenuation if not calculated
    - Rain/snow cross sections
        - -- Backscatter (clutter)
        - -- Doppler
    - Apparent RMS velocity
        - -- Wind
        - -- Rain

Performance Data Required to Simulate Reciprocating Engines

Instrumentation Parameters

- Engine temperature - coolant, head, block
- Oil pressure
- Oil temperature
- Charging voltage
- Charging current
- Air pressure
- Hydraulic pressure

  } Usually for auxiliaries - brakes, steering, etc.
- Vacuum
- Manifold pressure
- Inlet air temperature
- RPM
- Exhaust temperature (for turbo or IR signature)
- Coolant quantity
- Oil quantity
- Fuel quantity (multiple tank)
- Fuel flow

Controls

- Ignition or fuel shut-off
- Starter
- Cold start
  - Enrichment (choke, etc.)
  - Heat (glow plugs)
  - Heat (shutters, etc.)
- Accelerator

Engine Transfer Function Information

- Horsepower as a function of:
  - Accelerator position
  - RPM
  - Ambient temperature
  - Ambient pressure
  - Relative humidity
  - Type fuel (multifuel capability)
  - Fuel map
  - Oil consumption
- Auxiliary loads
  - Hydraulic
  - Air
  - Vacuum
  - Electricity
  - Mechanical

Transmission Characteristics

- Accelerator position vs rpm and torque
- Operating efficiency at various accelerator positions, rpm, and torque
- Shift characteristics
  - Gear selection as a function of load, rpm
  - Accelerator position
  - Engine characteristics (vacuum, etc.)
  - Ambient pressure